GE Medical Systems **Invention Disclosure Form** 3000 North Grandview Blvd., W-710 P.O. Box 414, Waukesha WI 53188 (262) 544-3028; Dialcom: 8*320-3028	Docket No.: [redacted] Mail to: PATENT OPERATION, W-710 Date Received: [redacted]

- **Use as many pages in this word document as necessary.**
- **You may attach additional materials to support this disclosure, for example, Tech Notes and Drawings. Such submitted materials must be referenced in this disclosure form. Each page of these materials must be dated, signed and witnessed in the same manner as this invention disclosure.**

MODALITY: *CT Detector Engineering- Global Components*

INVENTION TITLE: *Design and Method for Reflector with Very Low Cross-talk and High Light Output for CT Scintillator Array*

PROBLEM/BACKGROUND: The *current scintillator array (cast pack) for CT has one cast reflector coating. To reduce cross-talk, the reflector coating material contains significant amount of certain ingredient that can absorb the light transmitting across the separation boundaries between individual scintillator pixels. However, the light absorption significantly reduces the light output of the scintillator array by as much as 60%. In the mean time, the ability to reduce cross-talk is limited because the larger portion of the cross-talk is caused by the scattered X-ray that passes from one pixel to another. This scattered X-ray caused cross-talk can be estimated to be above 50% of the total. The addition of the cross-talk reducing agent significantly reduces the light output, but does not eliminate the X-ray caused cross-talk because it does not add significant absorption to X-ray. The invention proposed here will be able to significantly reduce cross-talk to improve CT image quality, but will simultaneously retain the high light output of the scintillator array. The high light output will significantly improve the signal to noise ratio and thus the image quality. Especially for the high resolution application with small pixels, this effect is highly desired.*

INVENTION DESCRIPTION: This disclosure presents the concept of a making the scintillator array with a reflector of sandwich structure that simultaneously retains high light output and low cross-talk. The reflector between scintillator pixels is composed of a middle layer of high-Z cast metal composite, and 2 outer layers of highly reflective coating on the scintillator surfaces. Figure 1 shows the partial structure of a scintillator array with this proposed cast reflector. The metal composite layer is composed of high-Z metal powder and low-viscosity polymer that can be cured at room temperature or elevated

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temperature. The heavy metal include high-Z metals such as tungsten (W), tantalum (Ta), or other heavy metal powder with density greater than $16g/cm^3$. The polymer material can be low-viscosity epoxy such as EpoTek 301, which is commercially available, or other commercially available epoxies. It can also be commercially available polyurethane. There is no color requirement for this polymer material. Practically darker color will be beneficial to the performance of the scintillator array. The thickness of this metal composite layer is about 50 to 100 µm. The metal powder with a particle size of 0.5 to 5 µm will be homogeneously mixed with the polymer and be cast-able. The polymer material shall have reasonable radiation resistance. The metal composite layer can completely absorb visible light that is transmitted from one pixel to another, thus completely eliminating the optical cross-talk in the scintillator. It can also absorb up to 50% of the x-ray photons across the gap between pixels, thus reducing the x-ray caused cross-talk to 50%. Currently the optical cross-talk is about 45% and x-ray cross-talk is about 55% of the total cross-talk. Therefore the final total cross-talk of the scintillator arrays with this proposed sandwich structure reflector will be only about 20% to 30% of the current scintillator arrays. The metal composite layer will also greatly reduce x-ray punch-through by ~ 60%. The two highly reflective layer is composed of reflector material contains only TiO_2 and radiation resistant epoxy or other cast-able polymer with a TiO_2 load of 40% to 70wt%. This reflector material has a reflectivity of about 95 – 99% with a certain surface roughness of 0.02 – 0.8 µm. Each layer has a thickness of about 15 to 50 µm.

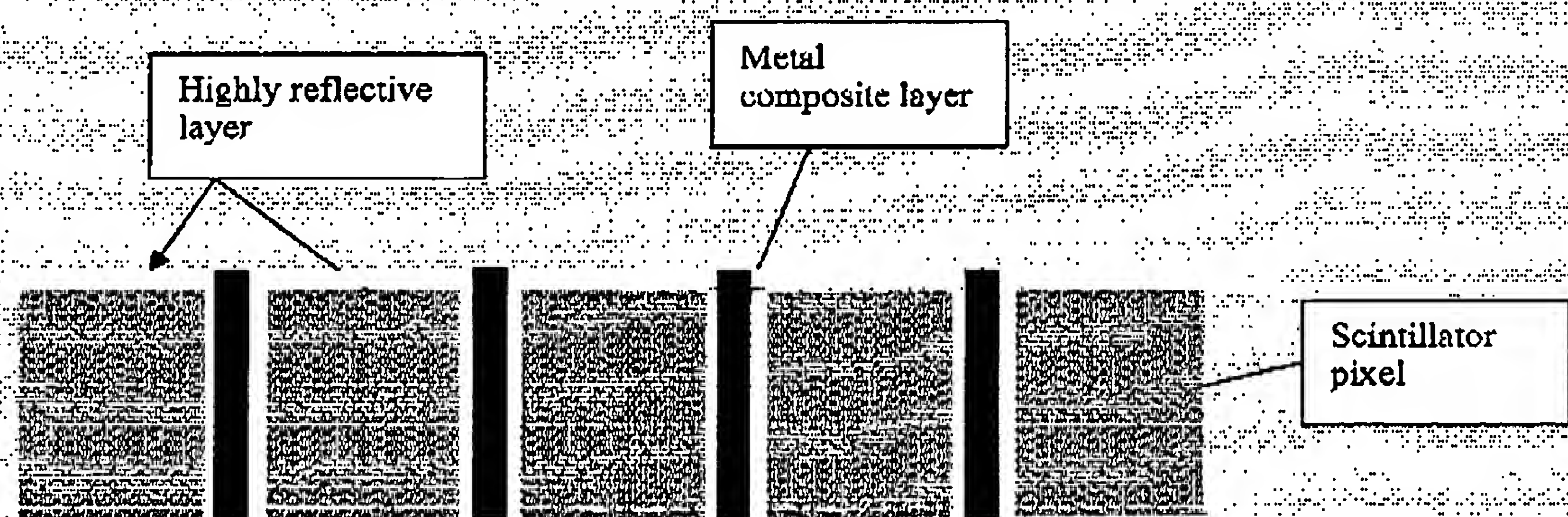

Figure 1. The structure of the sandwich cast reflector with high light output and low crosstalk.

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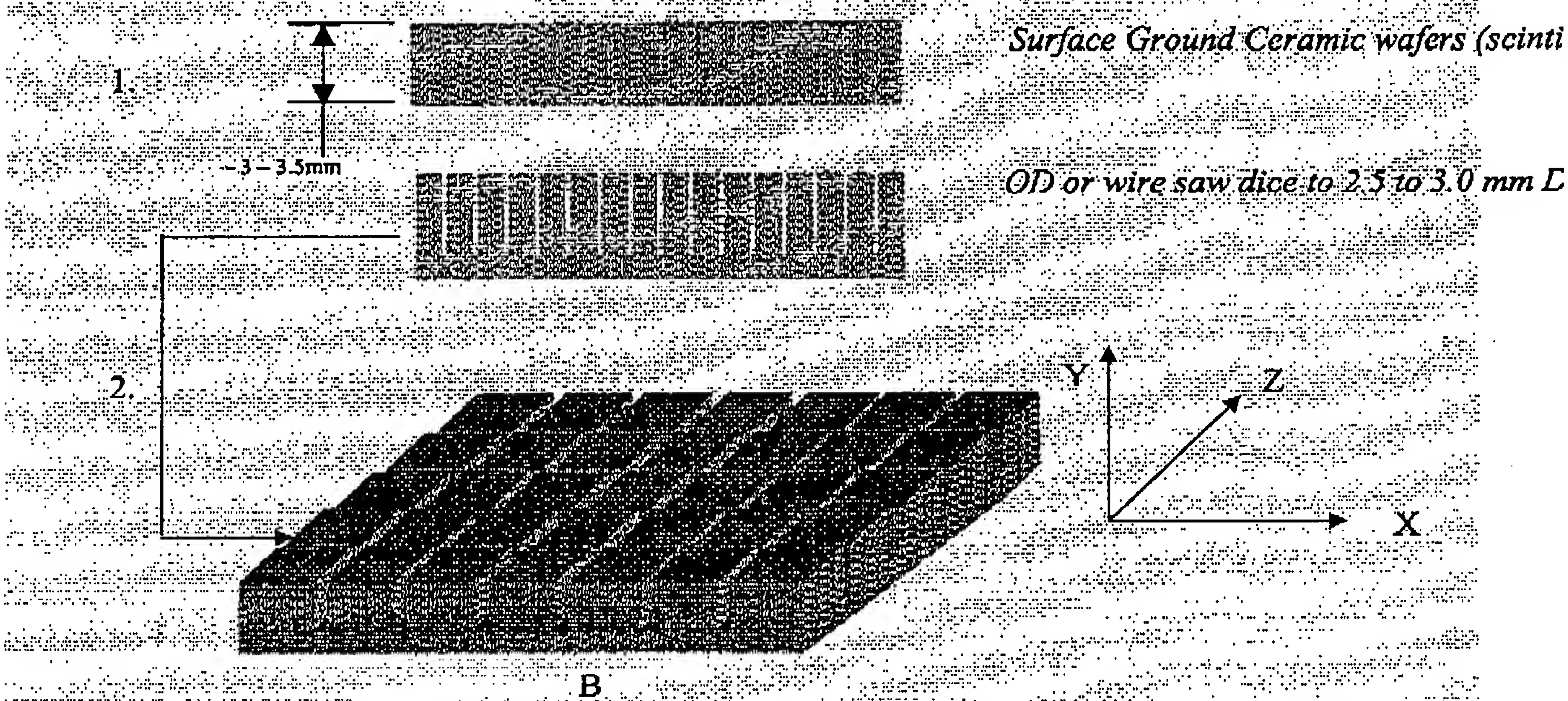
DRAWING: *The general description of this process is shown in Figure2 below.*



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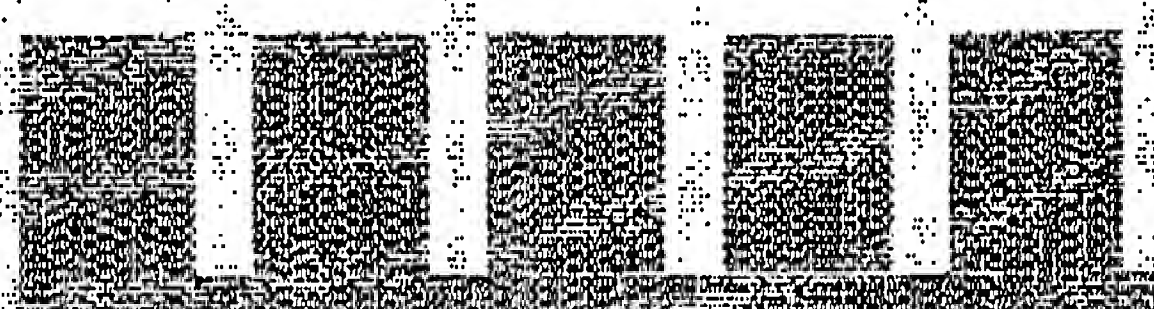
3. 

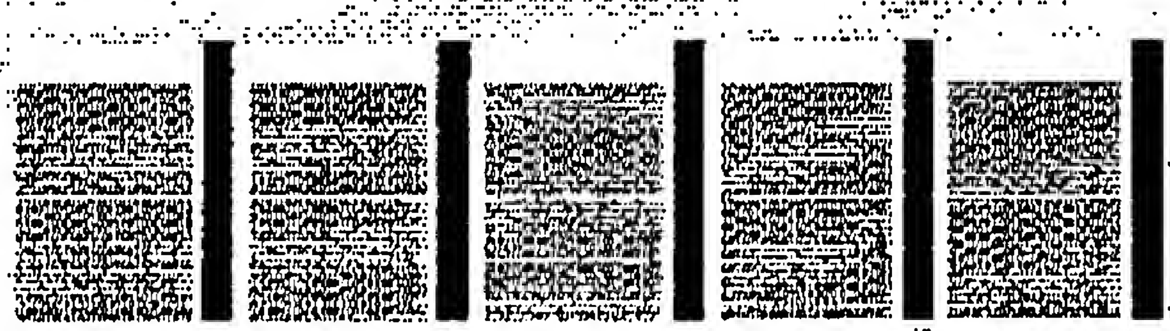
Cast with the highly reflective material containing TiC reflector surface.

4. 

Cut gaps in the middle of every cast line i saw, laser beam, OD saw, and other simil

5. 

Cast gaps with the metal powder – low vis remove extra metal composite material.

6. 

Grind the bottom surface to remove the ex desired x-ray stopping power.

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Figure 2. The process of making the scintillator arrays with the sandwich cast reflector structure that allows high light output and low crosstalk.

Figure 2 shows the process steps to make a scintillator array with the proposed cast reflector. In the first step, a scintillator wafer will be ground to a certain thickness on both sides so they are parallel. Then the wafer will be cleaned to remove any contaminates. The second step will produce a scintillator perform with pixilated structure. This process can be done on an OD dicer or a wire saw dicer. The gaps between pixels in both x and z directions have a width of about 100 to 200 μm depending on the requirement of geometric dose efficiency. The depth of the gaps depends on the stopping power requirement and will vary for different scintillator materials. In the third step, the highly reflective cast material containing 40 to 70wt% TiO_2 will be cast into the gaps. However, the cast filler is not limited to TiO2. Other highly reflective materials such as Ta_2O_5, HfO_2, Bi_2O_3, PbO, etc., can also be used. These materials do not have as high reflectivity as TiO_2, but they have much higher x-ray stopping power that can help reduce cross-talk between scintillator cells. The parts will be cured at a temperature depending on the polymer material. After curing, the top surface of the array will be machines to leave the top reflector layer of about 200 μm thick. The fourth step is the center of this invention. In this step the gaps between pixels in both x and z directions are recreated so the center layer of metal powder composite can be cast to form the sandwich cast reflector. Several methods can be used to cut these gaps. One method is using laser beam. A Nd:YAG laser, CO_2 laser, Ar^+ laser, or semiconductor laser can be used to machine these gaps. The laser beam will be focused on the center of middle of the cast lines. The width of the cut can be adjusted by adjusting the beam size with an optical aperture. The beam positioning can be done accurately with a vision system or mechanical fixture. The second method of machining these gaps is wire saw dicing. A wire with a diameter of 70 μm or less can be used to cut these gaps. The wires will be positioned on a spool with desired pitch. A mechanical fixture will be used to accuratcly position the wires and spool. 2 different wires can be used. One option is to use a metal wire with grinding media slurry feeding with the wires. The wires pass through the parts and create the cuts. The grinding media can be diamond, SiC powder, Alumina, and other grinding media powder with a grid size of 1000 to 3000 mesh. The second option for the wire is a metal wire embedded with diamond or SiC media. The third method of machining the gaps is OD saw dicing. The process will be similar to wire saw cutting. After machining, all pixels will have a highly reflective coating on all side surfaces with a thickness of about 15 to 50 μm.

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The fifth step is to cast the metal powder composite into the gap to form a sandwich reflector. A high-Z metal such as tungsten (W) or tantalum (Ta) will be selected because of their high x-ray stopping power. The metal powder will have a particle size of 0.5 to 5 μm. A low viscosity polymer such as epoxy EpoTek 301 (commercially available), polyurethane (commercially available), or other low viscosity polymer is selected as the binder. 40 to 60vol% of the metal powder is homogeneously mixed with the liquid polymer. The mixture is cast into the gaps created in step 4. After casting, the parts will be cured according to the polymer cure requirement.

Other methods of implementing the center metal film are also available. For instance, the high-Z metal particles can be coated with an adhesive binder material such as thermoplastic polymer coating. Then the coated metal particles can be cast into the gap with small amount of solvent such as alcohol. Then the solvent will be vaporized. The part will be heated to melt the thermoplastic coating that will bind all particles together and also serve as adhesive between the scintillator cells. Another method is coating the high-Z particles such as W with low-temperature solder film. The solder film will be melted later after the particles are cast into the gaps. The solder film will function as the thermoplastic film.

After the metal film is formed, the array will be ground or milled on the top surface to remove extra material of the metal composite and the TiO_2 containing reflector. The final top reflector thickness will be about 50 to 200 μm to maximize light output while minimizing the x-ray attenuation from the top reflector.

The sixth or the final step is to machine the array into the final dimension. The bottom surface will be ground to remove the extra scintillator material and to attain a final thickness of the thickness of about 1.5 to 3 mm according to the type of the scintillator. This surface will be coupled with photodiode in the detector array.

ADVANTAGES OF THE INVENTION: *This design has the following advantages:*

1) *High light output of the scintillator arrays – 30% to 50% higher than current scintillator arrays.*
2) *Lower cross-talk, about 20 to 30% of current scintillator arrays.*
3) *Improved image quality of CT system due to higher signal to noise ratio.*
4) *Improved image quality due to lower cross-talk.*
5) *Can be used for any scintillator material such as GE HighLight, GOS, and other scintillators.*

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6) *Less x-ray punch through and less damage to the diodes.*
7). *Applicable for any dimensional multi-pixelated scintillator arrays.*

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CLAIM OF NOVELTY:

1. *The sandwich structure of cast reflector.*
2. *The sandwich type reflector with a cast-able metal composite at the middle layer that eliminates optical cross-talk and greatly reduces x-ray caused cross-talk.*
3. *The sandwich reflector with two outer layers of highly reflective cast-able coating that retains high light output.*
4. *The castable metal composite composed of high-Z metal such as tungsten (W), tantalum (Ta), or other heavy metals; and low viscosity polymers such as epoxy, polyurethane, or other low viscosity polymers.*
5. *A method to use laser beam to machine gaps between pixels after first cast with highly reflective TiO_2 containing material.*
6. *A method to use wire saw dicing to machine gaps between pixels after first cast with highly reflective TiO_2 containing material.*
7. *A method to use OD dicing to machine gaps between pixels after first cast with highly reflective TiO_2 containing material.*

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SUMMARY QUESTIONS FOR INVENTION DISCLOSURE

(The answers to these questions will help the modality PEB with the patent filing decisions they make.)

1) **DESCRIBE ANY RECENT WORK ON DEVELOPING AND DEMONSTRATING THE IDEA AT GEMS.** *Has feasibility been proven? How? Is there a prototype?*

[redacted]

2) **ARE THERE ANY PLANS TO USE THE INVENTION IN A PRODUCT?** *Give Product/Program name and milestone dates if known. Has this invention been identified as a program deliverable?*

[redacted]

3) **WHAT ARE THE PLANS OR DESIRES TO PUBLISH?** *It is absolutely critical to identify the earliest possible public disclosure of the invention for legal reasons. This may include publication, installation of prototype, trade shows, etc. GEMS can lose the right to patent an invention by premature public disclosure.*

[redacted]

4) **DESCRIBE ANY KNOWN RELEVANT COMPETITOR ACTIVITY.** *Are any competitors working on solutions to the same problem? Have any competitors addressed the same problem?*

[redacted]

5) **WAS THIS INVENTION DEVELOPED IN THE COURSE OF A PROJECT WHICH WAS FUNDED IN PART BY AN ENTITY OTHER THAN GE?** *Has any work been done, for example, with Government funding, university collaboration, even if such funding was provided indirectly, as via CRD?*

[redacted]

6) **WHAT IS THE EARLIEST TANGIBLE DOCUMENTATION OF THIS INVENTION?** *Is it a lab notebook, engineering report, etc., or this disclosure document? If not this document, please provide a reference and a date.*

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7) **HOW MUCH DIFFICULTY WOULD A COMPETITOR EXPERIENCE IN TRYING TO DESIGN AROUND THIS INVENTION?** *Are there many ways of relatively equal difficulty to solve the problem, or is the invention a unique solution in terms of benefit and simplicity?*

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